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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2017/2018

EEL4126 – POWER SYSTEM OPERATION AND CONTROL (LE)

6 JUNE 2018
2:30pm-4:30pm
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 4 pages including the cover page with 4 Questions only.
2. Answer **ALL** questions. The distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

- (a) The incremental fuel cost in RM/MWh for three units of thermal plant are

$$\begin{aligned} IC_1 &= 0.028P_1 + 5.0 & IC_2 &= 0.007P_2 + 3.0 \\ IC_3 &= 0.04P_3 + 7.0 \end{aligned}$$

If all three units are to operate to meet the total load of 800 MW, design a system with each unit of the thermal plant generating most economically. [7 marks]

- (b) Explain the importance of Unit Commitment from the perspective of the utility. [3 marks]

- (c) A Unit Commitment problem can be solved by several methods. You are tasked to assist the utility company, TNB to compute the minimum cost by identifying the optimum combination. The demand profile and relevant unit data is as shown in Table 1 and Table 2. Design the optimum scheme of Unit Commitment to meet the demand profile. It is assumed that Unit A has been running for sufficiently long time before being subjected to the demand as profiled in Table 1. [15 marks]

Table 1: Demand Profile

Period in hour	1	2	3	4	5	6
Load in MW	260	330	300	250	250	200

Table 2: Unit Data

Unit	$P_{\min}$ (MW)	$P_{\max}$ (MW)	Min up (h)	Min down (h)	No- load cost (RM)	Marginal cost (RM/MWh)	Start- up cost (RM)	Initial status
A	200	260	1	1	0	40	4,000	ON
B	50	100	2	1	0	50	1,000	OFF
C	10	100	1	1	0	80	500	OFF

Continued...

Question 2

- (a) Explain the importance of power system security. [2 marks]
- (b) List and explain the two types of power system constraints. [4 marks]
- (c) The advantage of DC power flow method lies in its speed of computing solution in a contingency analysis with adequate accuracy. There are several assumptions being made for DC power flow. Identify two of them. [2 marks]

- (d) A 3-bus power system is shown in Figure Q2 with all the values in per unit.

Analyse the power system and

- determine the base power flows on the transmission lines. [11 marks]
- calculate the generation shift factors for all lines for a change in Generator 2 (G2). [3 marks]
- compute the line outage distribution factor for line 2-3 for an outage of line 1-2 and the power flow in line 2-3 after the outage. [3 marks]

[Hint: The line outage distribution factor for line l connected between buses i and j for an outage of line k connected between buses n and m is given by

$$\frac{x_k (X_{in} - X_{jn} - X_{im} + X_{jm})}{x_l (x_k - (X_{nn} + X_{mm} - 2X_{nm}))}$$

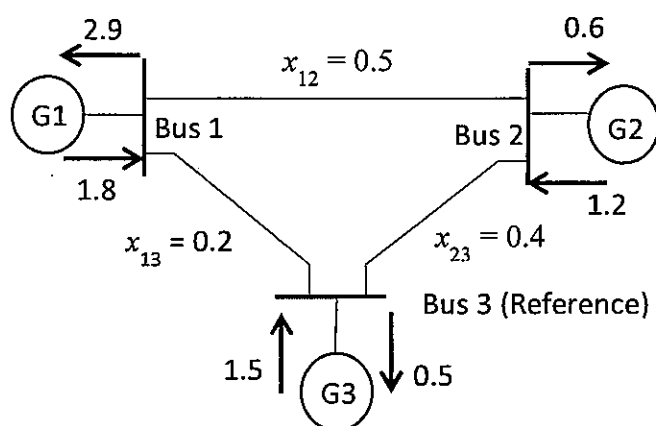


Figure Q2

Continued...

Question 3

- (a) Draw the block diagram of a generator model. [5 marks]
- (b) Consider a single 800 MVA generator supplying a service area. At a given instant of time, the system operates at 60 Hz. The electric load is $P_D = 600$ MW, the per unit inertia constant is $H = 3.5$ s, the speed regulation (droop characteristic) is $R = 0.05$ p.u. and the load frequency characteristic is $D = 15$ MW/Hz.
- Compute the steady state condition of the system after a 10 MW increase in the electric load, and [10 marks]
 - Compute the required change in the set point to insure a 60 Hz operation. [10 marks]

Question 4

- (a) What are the requirements of excitation systems? [4 marks]
- (b) With the aid of a schematic diagram, explain the functions of each element of an excitation system. [10 marks]
- (c) An Automatic Voltage Regulator (AVR) system of an alternator has the parameters given in Table Q4.

Table Q4

<i>Component</i>	<i>Gain</i>	<i>Time constant (s)</i>
Amplifier	$K_A = 10$	$\tau_A = 0.1$
Exciter	$K_E = 1$	$\tau_E = 0.4$
Generator	$K_G = 1$	$\tau_G = 1.0$
Sensor	$K_S = 1$	$\tau_S = 0.05$

- Draw the block diagram of the AVR. [4 marks]
- Determine the closed-loop transfer function, and [4 marks]
- Compute the steady state error for the unity step response. [3 marks]

End of the Paper.

